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DRY-LAND GARDENING AT THE NORTHERN GREAT PLAINS FIELD STATION, MANDAN, N. DAK.

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INTRODUCTION

The Northern Great Plains Field Station is located at Mandan, N. Dak., in the eastern part of the northern Great Plains. It is one of a number of experiment stations at which the Office of Dry-Land Agriculture of the Bureau of Plant Industry is studying the possibilities of agriculture under dry-land conditions.

The station was established in 1913, when ground was broken and buildings were erected. Horticultural investigations were begun on a small scale the same year, but the main work was not started until 1914.

From 1914 to 1918 the work in gardening, one of the branches of horticulture, consisted mainly in testing varieties of vegetables commonly grown under field culture by various cultural methods. From data obtained during these years and from other experience in gardening by the writer a system of vegetable culture under dry-land conditions for farms in this region was evolved and has been in operation since 1920.

It is the object of this bulletin to outline the system followed and to discuss the results that have been obtained with it, thus showing in a general way how vegetable growing can be fairly successful under dry-land conditions in the northern Great Plains.

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CLIMATE

The climate of the northern Great Plains is not well adapted to general horticulture. The scant precipitation; the frequent winds sweeping over the generally unprotected farmsteads; the high rate of evaporation, generally highest in the seasons of lowest precipitation; and the short growing seasons, indefinite because of irregularity in the dates of killing frosts in the spring and fall, are difficulties with which the growers in this region must contend.

Complete climatic data have been recorded at the station since its establishment. Similar records have been kept since 1875 by the United States Weather Bureau station at Bismarck, N. Dak., 5 miles east of Mandan.

The 50-year mean annual precipitation is about 17 inches. The month of maximum precipitation is June, with a mean of more than 3.5 inches, and the month of minimum precipitation is February, with less than 0.5 inch.

The average date of the last killing frost in the spring is about May 15 and that of the first in autumn is about September 15, but frost has occurred as late as June 3 and as early as August 23.

The prevailing wind direction is from the west or northwest. The average wind movement near the ground is about 6 miles an hour.

The monthly, the seasonal, and the annual precipitation at the field station for the five years from 1920 to 1924, inclusive, for which results with vegetables are reported in this bulletin, are given in Table 1. The period was one of unusually protracted drought. The annual precipitation averaged only 15.19 inches, and equaled the long-time average in only one of the five years.

TABLE 1.—*Monthly, seasonal, and annual precipitation at the Northern Great Plains Field Station for the five years from 1920 to 1924, inclusive*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Seasonal, Apr. to Sept.	Annual
1920	0.52	0.20	1.21	0.58	1.72	1.85	2.68	1.81	1.29	0.25	0.37	0.21	9.93	12.69
1921	.18	.09	.79	2.59	3.05	.82	3.38	.25	1.58	1.39	.87	.24	11.67	15.23
1922	.28	1.55	.52	.66	2.05	3.43	3.17	.32	2.31	.64	1.60	.82	11.94	17.35
1923	.36	.38	.16	1.85	1.18	1.94	4.12	1.15	2.31	.54	.28	.14	12.55	14.41
1924	.03	.25	.28	1.68	.41	5.56	2.07	2.35	1.34	1.94	.06	.28	13.41	16.25

From 69 to 87 per cent of the entire precipitation each year, however, was received during the growing season, from April to September, inclusive, and annual crops, such as most vegetables, were enabled to obtain the maximum benefit from it.

The dates of the last frost in the spring and the first frost in the fall and the length of the frost-free period for each of the five years under study are given in Table 2. During these five years the latest frost in spring was on May 24 and the earliest in fall on September 26. The frost-free period varied from 125 to 165 days and averaged 145 days.

TABLE 2.—*Dates of last frost in spring and first frost in fall, with temperatures recorded, and number of frost-free days at the Northern Great Plains Field Station for the five years from 1920 to 1924, inclusive*

Year	Last frost in spring		First frost in fall		Frost-free period (days)
	Date	Temperature (° F.)	Date	Temperature (° F.)	
1920	Apr. 27	18	Sept. 28	28	154
1921	May 14	28	Sept. 30	31	139
1922	Apr. 25	29	Oct. 7	26	165
1923	May 14	29	Oct. 4	32	143
1924	May 24	23	Sept. 26	31	125
Average	May 9		Oct. 1		145

GARDENING EXPERIMENTS

As a workable rotation system and the judicious selection of varieties are of interest and importance to gardeners on the northern Great Plains, the results over an extended period of time in the garden at the Northern Great Plains Field Station are presented in detail.

EXPERIMENTAL METHODS

The size of the garden is approximately an acre. Its dimensions are 160 feet north and south by 272 feet east and west. The rows run north and south.

A definite four-year rotation system and a well-matured planting plan are followed. Standard varieties are used, and the seed for them is obtained from the same sources each year.

The length of row or number of hills of each vegetable is approximately constant from year to year, and is based on tentative estimates of the quantities required for a family of five, with possible small surpluses for disposal. Wide spacing is practiced.

Each vegetable is harvested when it is ready for the table or for market or storage. The yields are determined and the records kept in units of quarts, pounds, fruits, etc., according to the market practice with the different vegetables.

THE ROTATION SYSTEM

An adequate system of rotation in a garden offers three advantages: (1) The accommodation of the various vegetable crops to their different requirements for manure and soil moisture; (2) the elimination of plant diseases and insect pests; and (3) the use of a permanent garden site, which enables the grower to provide necessary shelter with windbreaks or hedges. Various parts of different vegetables are made use of as food, such as the fleshy roots of some, the succulent leaves of others, and the fruits and seeds of still others. Accordingly they may be classified as root crops, leaf crops, etc. Each crop has special requirements of soil, fertilizers, and moisture for its best development. The rotation system in use at the field station is based on these requirements.

The vegetables are divided into four classes or groups, as follows: Leaf crops, root crops, leguminous crops, and vine crops and early potatoes. The garden area is divided accordingly into four plats of equal size, each plat being occupied during a season by one of the crop groups. Leaf crops require a soil rich in nitrogen, which is obtained in freshly manured soil. The plat on which such crops are grown may be manured heavily with rotted or half-rotted stable manure. The root crops require a rich soil, but not a freshly manured one, as fresh manure causes fibrous roots and excessive leaf development; hence they may properly follow the leaf crops in the rotation. The legumes are not exacting in their requirements and may follow the root crops. They use comparatively little water and leave the ground improved for the vine crops to follow in the fourth year.

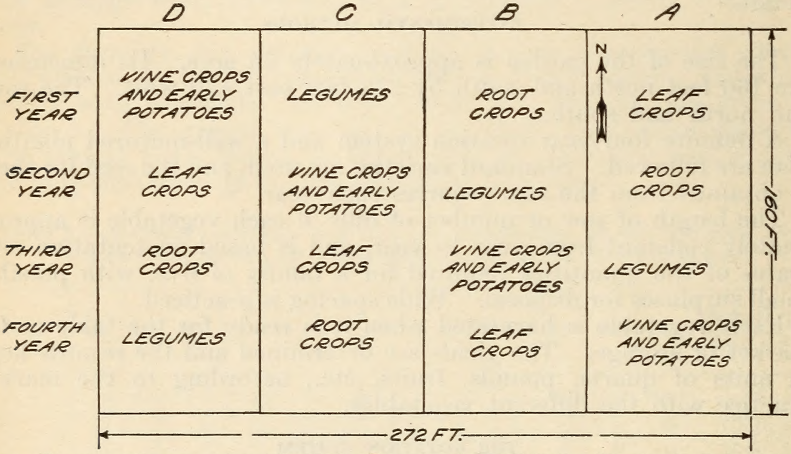
The vegetables included in the four groups are as follows:

Leaf crops.—Cabbage, cauliflower, and sweet corn. Cauliflower and sweet corn are not leaf crops, but are included with them because they require the same soil conditions and because their inclusion here equalizes the area of ground required for each group.

Root crops.—Beets, carrots, parsnips, rutabagas, onions, tomatoes, peppers, and eggplant. The latter four are not root crops, but may be included with them, as they require the same soil conditions.

Legumes.—Peas, wax-pod beans, and shell beans.

Vine crops and early potatoes.—Pumpkin, squashes, watermelons, muskmelons, cucumbers, and early potatoes.



	D	C	B	A
FIRST YEAR	VINE CROPS AND EARLY POTATOES	LEGUMES	ROOT CROPS	LEAF CROPS
SECOND YEAR	LEAF CROPS	VINE CROPS AND EARLY POTATOES	LEGUMES	ROOT CROPS
THIRD YEAR	ROOT CROPS	LEAF CROPS	VINE CROPS AND EARLY POTATOES	LEGUMES
FOURTH YEAR	LEGUMES	ROOT CROPS	LEAF CROPS	VINE CROPS AND EARLY POTATOES

FIG. 1.—Diagram of the acre garden at the Northern Great Plains Field Station, Mandan, N. Dak., showing the division into four plats and the rotation on them for one cycle of four years

Figure 1 presents a sketch of the garden at the field station, showing the division into four plats and the rotation on them for four years.

Short-season crops, such as radishes, lettuce, and spinach; special crops, like celery; and perennial crops, such as asparagus, horseradish, and rhubarb, were not included in the main garden at the station, but for convenience were grown in a special plat near to the dwellings. They may be included in the main garden, however, the perennial ones being planted at the edge, where they will not interfere with the rotation; the celery, lettuce, and spinach among the leaf crops; and the radishes among the root crops.

Figures 2 to 5 show the vegetables in the four sections of the garden as they appeared on July 25, 1924.

THE VARIETIES USED

Preliminary work at the field station from 1913 to 1918 brought out the fact that certain types and varieties were more dependable and gave better average results than others. In general it was found that varieties making the most of their growth during June and July, when the moisture is most abundant and the days fairly cool, succeeded best. Some varieties also proved more resistant to disease than others. The Earliana variety of tomatoes, the Copenhagen Market and the Wakefield varieties of cabbage, the Golden Bantam and the Cory varieties of sweet corn, and the Globe varieties of onions may be cited as examples of especially dependable varieties.

To extend the season of each vegetable, succession plantings of the most suitable variety were found in most cases to be preferred to one planting of two or more varieties of different season, and in the station garden the practice of two plantings of vegetables that do not require the entire season has been followed.

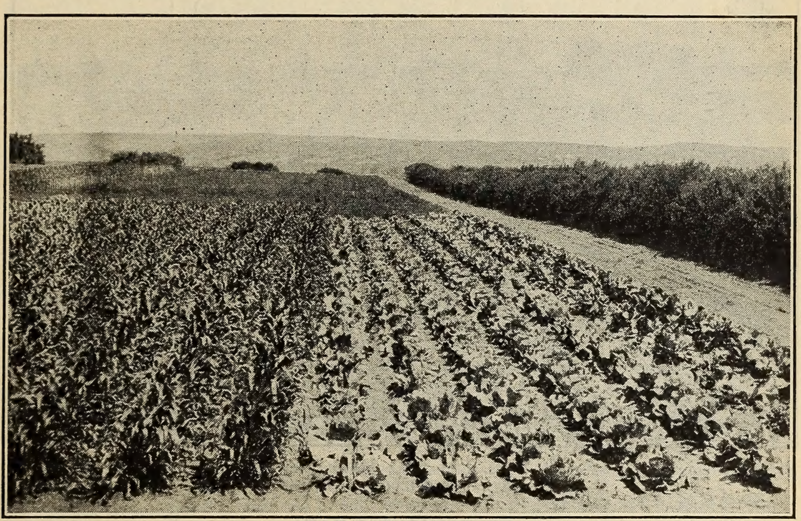


FIG. 2.—Sweet corn, cauliflower, and cabbage in the leaf-crop plat of the acre garden on July 25, 1924

The following varieties of vegetables were selected for the garden project at the field station as representative of dependable standard varieties carried by most seed firms:

Asparagus: Reading Giant.

Bean, wax-pod—Burpee's Saddleback, Kidney Wax; shell, or navy—Pilot.

Beets, early bunching—Eclipse; fall—Detroit Dark Red.

Cabbage, early—Copenhagen Market, Jersey Wakefield; fall—Copenhagen Market (late planted), Danish Roundhead.

Carrots: Chantenay.

Cauliflower, early—Burpee's Best Early, Dwarf Erfurt; fall—Snowball (late planted), Dry Weather.

Celery: Golden Self-Blanching, Fordhook.

Cucumbers: Fordhook Famous (White Spine variety).

Eggplant: Black Beauty.

Lettuce, leaf—Black-Seeded Simpson, Grand Rapids; head—Wayahead, Salamander, Hanson.

Muskmelons: Emerald Gem.
Onions: Southport Yellow Globe, Australian Brown.
Parsnips: Improved Guernsey.
Peas, smooth—Alaska; wrinkled—Notts Excelsior.
Peppers: Ruby King.
Potato: Early Ohio.
Pumpkin: Small Sugar.
Rutabagas: Golden Neckless.
Spinach: Victoria.
Squashes, summer—Cocozelle; winter—Golden Hubbard.
Sweet corn: Golden Bantam.
Tomato: Sunnybrook Earliana.
Watermelons: Fordhook Early.

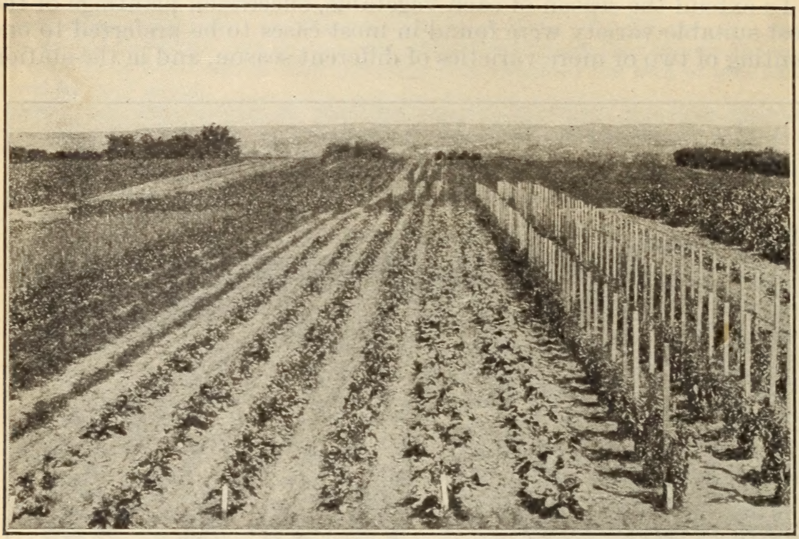


FIG. 3.—Onions, parsnips, carrots, beets, rutabagas, eggplants, and tomatoes in the root-crop plat of the acre garden on July 25, 1924

EXPERIMENTAL DATA

The experimental data from the acre rotation garden at the field station for the five years from 1920 to 1924, inclusive, are given in Table 3. This table gives, for each vegetable each year, the variety, the date of planting, the length of row or number of hills, the planting distance, the stand, the date when first ready for use, the total yield, and the rate of yield per 100 feet of row or 10 hills.

Asparagus, rhubarb, spinach, lettuce, radishes, and celery do not appear in this table. They were grown each year with excellent results, but the yields were not determined, and only notes as to season and quality were taken on them.

During the five years there were some slight deviations from a uniform plan. These were owing to a few experimental investigations, principally a search for a good winter-keeping variety of cabbage, and to the addition of peppers and eggplant, which were not at first included in the vegetable list. The list of varieties employed in 1923 and 1924 is now considered the most satisfactory available, and its use will be continued.

TABLE 3.—*Data in regard to planting, yield, etc., of vegetables in the acre garden at the Northern Great Plains Field Station, Mandan, N. Dak., from 1920 to 1924, inclusive*

Vegetable, class, and variety	Year	Date planted	Row length or number of hills (feet)	Planting distance (inches)	Stand (per cent)	Date when first ready	Yield		
							Total	Per 100 feet of row, or 10 hills	Unit of measure
Beans, shell:									
Pilot	1920	May 10	640	36 by 3	100	Sept. 10	42	6.6	Pounds.
Great Northern	1920	do	960	do	100	do	65	6.8	Do.
Pilot	1921	May 18	1,440	do	75	Sept. 21	18	1.3	Do.
Do	1922	May 15	1,440	do	95	Sept. 19	120	8.3	Do.
Do	1923	May 10	1,440	do	100	Sept. 25	105	7.3	Do.
Do	1924	May 14	1,280	do	100	Sept. 20	110	8.6	Do.
Beans, wax:									
Saddleback	1920	May 7	320	36 by 5	90	July 17	77	24.1	Quarts.
Kidney	1920	May 3	320	do	90	do	43	13.4	Do.
White	1920	May 10	320	do	80	July 27	70	21.9	Do.
Saddleback	1921	do	320	do	95	Aug. 24	5	1.6	Do.
Do	1921	June 2	320	do	85	Aug. 3	12	3.8	Do.
Kidney	1921	May 18	320	do	65	do	12	3.8	Do.
Do	1921	June 2	320	do	65	Aug. 12	13	4.1	Do.
Saddleback	1922	May 9	320	do	75	July 8	168	52.5	Do.
Do	1922	June 1	320	do	65	Aug. 3	124	38.8	Do.
Kidney	1922	May 9	320	do	75	July 12	189	59.1	Do.
Do	1922	June 1	320	do	65	Aug. 3	42	13.1	Do.
Saddleback	1923	May 5	320	do	60	July 10	119	37.2	Do.
Do	1923	May 25	320	do	85	July 14	103	32.2	Do.
Kidney	1923	May 5	320	do	35	do	77	24.1	Do.
Do	1923	May 25	320	do	75	July 24	76	23.8	Do.
Saddleback	1924	May 7	320	do	65	do	99	30.9	Do.
Do	1924	May 28	320	do	85	July 28	134	41.9	Do.
Kidney	1924	May 7	320	do	65	July 24	103	32.2	Do.
Do	1924	May 28	320	do	75	Aug. 2	93	29.1	Do.
Beets, early:									
Eclipse	1920	Apr. 28	320	36 by 3	95	July 6	150	46.9	Pounds.
Do	1921	May 6	320	do	100	July 13	156	48.8	Do.
Do	1922	May 9	320	do	75	July 10	268	83.8	Do.
Do	1923	Apr. 21	320	do	35	July 21	190	59.4	Do.
Eclipse (mixed)	1924	Apr. 22	320	do	85	Aug. 2	355	110.9	Do.
Beets, fall:									
Detroit Dark Red	1920	May 10	320	36 by 5	100	Sept. 28	218	68.1	Do.
Do	1921	May 18	320	do	85	Sept. 21	207	64.7	Do.
Do	1922	May 22	320	do	65	Sept. 15	558	174.4	Do.
Do	1923	May 25	320	do	65	Sept. 22	420	131.3	Do.
Do	1924	May 28	320	do	98	Oct. 8	613	191.6	Do.
Cabbage, early:									
Jersey Wakefield [1] Copenhagen Market	1920	Mar. 15	480	36 by 24	75	July 12	485	101.0	Do.
Jersey Wakefield	1921	do	160	do	100	July 18	89	55.6	Do.
Copenhagen Market	1921	do	160	do	98	July 22	272	170.0	Do.
Jersey Wakefield	1922	do	160	do	85	July 28	386	241.3	Do.
Copenhagen Market	1922	do	160	do	85	July 15	701	438.1	Do.
Jersey Wakefield	1923	do	160	do	15	July 30	38	23.8	Do.
Copenhagen Market	1923	do	160	do	15	July 27	140	87.5	Do.
Jersey Wakefield	1924	do	160	do	98	Aug. 2	184	115.0	Do.
Copenhagen Market	1924	do	160	do	100	do	530	331.3	Do.
Cabbage, fall:									
Copenhagen Market	1920	Apr. 15	320	do	65	Aug. 4	195	60.9	Do.
Do	1921	Apr. 20	320	do	80	Sept. 2	285	89.1	Do.
Enkhuizen Glory	1921	do	160	do	75	Sept. 21	245	153.1	Do.
Copenhagen Market	1922	Apr. 27	320	do	85	Aug. 17	614	191.9	Do.
Surehead	1922	do	160	do	90	Sept. 14	448	280.0	Do.
Copenhagen Market	1923	May 1	320	do	0	----------	0	0	
Autumn King	1923	do	160	do	0	----------	0	0	
Copenhagen Market	1924	Apr. 20	320	do	98	Aug. 15	864	270.0	Do.
Danish Roundhead	1924	do	160	do	98	Sept. 20	322	201.3	Do.
Carrots:									
Chantenay	1920	May 10	320	36 by 2	100	Sept. 28	145	45.3	Do.
Do	1921	May 6	160	do	95	Sept. 21	151	94.4	Do.
Do	1921	May 18	160	do	90	do	166	103.8	Do.
Do	1922	Apr. 29	160	do	95	Sept. 14	366	228.8	Do.
Do	1922	May 9	160	do	90	do	343	214.4	Do.
Do	1922	May 22	160	do	65	do	186	116.3	Do.
Do	1923	Apr. 21	160	do	90	July 21	190	118.8	Do.
Do	1923	May 10	160	do	75	Sept. 22	304	190.0	Do.
Do	1923	May 25	160	do	75	do	128	80.0	Do.
Do	1924	Apr. 22	160	do	75	July 25	60	37.5	Do.
Do	1924	May 7	160	do	98	Sept. 4	122	76.3	Do.
Do	1924	May 28	160	do	85	Oct. 6	108	67.5	Do.

[1] Jersey Wakefield and Copenhagen Market were used, but separate records were not kept.

TABLE 3.—*Data in regard to planting, yield, etc., of vegetables in the acre garden at the Northern Great Plains Field Station, Mandan, N. Dak., from 1920 to 1924, inclusive*—Continued

Vegetable, class, and variety	Year	Date planted	Row length or number of hills (feet)	Planting distance (inches)	Stand (per cent)	Date when first ready	Yield		
							Total	Per 100 feet of row, or 10 hills	Unit of measure
Cauliflower, early:									
Burpee's Best Early	1920	Mar. 15	160	36 by 24	90	June 22	46	28.8	Pounds.
Do	1921	Mar. 17	160	do	65	June 29	28	17.5	Do.
Do	1922	Mar. 15	160	do	95	July 7	135	84.4	Do.
Do	1923	do	160	do	10	Aug. 14	4	2.5	Do.
Do	1924	do	160	do	98	July 24	106	66.3	Do.
Cauliflower, fall:									
Snowball	1920	Apr. 15	160	do	65	Sept. 28	8	5.0	Do.
Do	1921	Apr. 20	160	do	12		0	0	
Do	1922	Apr. 27	160	do	85	Sept. 10	81	50.6	Do.
Do	1923	May 1	160	do	0		0	0	
Dry Weather	1924	Apr. 20	160	do	98	Aug. 7	92	57.5	Do.
Eggplant:									
Black Beauty	1923	Mar. 15	160	do	100	July 27	112	70.0	Fruits.
Do	1924	do	80	do	75	Sept. 2	9	11.3	Do.
Onions:									
Australian Brown	1920	Apr. 28	640	18 by 3	65	Sept. 28	135	21.1	Pounds.
Southport Yellow Globe.	1920	do	960	18 by 2	75	do	226	23.5	Do.
Do	1921	Apr. 22	1,920	do	75	Sept. 21	388	20.2	Do.
Do	1922	Apr. 25	1,280	do	100	Sept. 2	773	60.4	Do.
Australian Brown	1922	do	480	do	85	do	124	25.8	Do.
Southport Yellow Globe.	1923	Apr. 21	1,760	do	95	Sept. 6	1,332	75.7	Do.
Do	1924	Apr. 22	1,760	do	98	Sept. 15	1,195	67.9	Do.
Parsnips:									
Guernsey	1920	Apr. 28	320	36 by 3	65	Sept. 28	67	20.9	Do.
Improved Guernsey	1921	Apr. 22	320	do	90	Sept. 21	97	30.3	Do.
Do	1922	Apr. 25	320	do	95	Sept. 26	335	104.7	Do.
Do	1923	Apr. 21	320	do	90	Sept. 22	450	140.6	Do.
Do	1924	Apr. 22	320	do	98	Oct. 8	429	134.1	Do.
Peas:									
Alaska	1920	Apr. 28	160	36 by 1	50	June 22	7	4.4	Quarts.
Notts Excelsior	1920	May 4	480	do	85	July 1	22	4.6	Do.
Alaska	1921	Apr. 22	320	do	100	June 21	24	7.5	Do.
Notts Excelsior	1921	May 6	320	do	100	June 28	11	3.4	Do.
Do	1921	May 18	320	do	98	July 1	14	4.4	Do.
Alaska	1922	Apr. 25	320	do	75	June 24	45	14.1	Do.
Notts Excelsior	1922	May 9	320	do	75	July 1	71	22.2	Do.
Do	1922	May 22	320	do	65	July 22	44	13.8	Do.
Alaska	1923	Apr. 21	320	do	90	June 18	39	12.2	Do.
Notts Excelsior	1923	May 4	320	do	75	June 26	52	16.3	Do.
Do	1923	May 18	320	do	75	July 10	40	12.5	Do.
Alaska	1924	Apr. 22	320	do	90	July 3	88	27.5	Do.
Notts Excelsior	1924	May 7	320	do	95	July 15	71	22.2	Do.
Do	1924	May 28	320	do	95	July 22	76	23.8	Do.
Peppers:									
Ruby King	1924	Mar. 15	80	36 by 24	100	Aug. 15	179	223.8	Fruits.
Potato:									
Early Ohio	1920	May 16	1,240	36 by 20	98	July 14	800	64.5	Pounds.
Do	1921	Apr. 30	480	do	100		(2)		
Do	1921	May 15	960	do	95		(2)		
Do	1922	May 12	1,440	do	98	July 18	1,125	78.1	Do.
Do	1923	May 6	1,440	do	98	July 14	1,138	79.0	Do.
Do	1924	May 7	1,440	do	90	Aug. 11	1,068	74.2	Do.
Rutabagas:									
Golden Neckless	1920	May 3	160	36 by 5	98	Sept. 28	135	84.4	Do.
Do	1921	May 18	160	do	75	Sept. 21	75	46.9	Do.
Do	1922	May 22	320	do	98	Sept. 26	300	93.8	Do.
Do	1923	May 23	320	do	100	Sept. 23	500	156.3	Do.
Do	1924	May 28	320	do	100	Aug. 22	457	142.8	Do.
Sweet corn:									
Golden Bantam	1920	May 3 [3]	2,560	36 by 20	80	Aug. 11	242	9.5	Ears.
Do	1921	May 6	1,280	do	85	Aug. 18	30	2.3	Do.
Do	1921	June 2	1,280	do	98	Aug. 23	470	36.7	Do.
Do	1922	May 9 [4]	1,280	do	75	Aug. 9	700	54.7	Do.
Do	1922	June 2	1,280	do	85	Aug. 23	700	54.7	Do.
Do	1923	May 1	1,280	do	100	Aug. 4	920	71.9	Do.
Do	1923	May 25	1,120	do	100	Aug. 18	648	57.9	Do.
Do	1924	May 7	1,280	do	65	Aug. 28	1,230	96.1	Do.
Do	1924	May 29	1,120	do	100	Sept. 9	1,270	113.4	Do.

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[2] Yield good, but data were lost.

[3] One half planted May 3 and the other half May 16.

[4] Only 5 per cent stand obtained. Replanted May 20.

TABLE 3.—*Data in regard to planting, yield, etc., of vegetables in the acre garden at the Northern Great Plains Field Station, Mandan, N. Dak., from 1920 to 1924, inclusive*—Continued

Vegetable, class, and variety	Year	Date planted	Row length or number of hills (feet)	Planting distance (inches)	Stand (per cent)	Date when first ready	Yield		
							Total	Per 100 feet of row, or 10 hills	Unit of measure
Tomato:									
Earliana	1920	Mar. 15	480	36 by 30	98	July 22	458	95.4	Pounds.
Sunnybrook Earliana.	1921	do	480	do	98	July 15	354	73.8	Do.
Do	1922	Mar. 20	480	do	100	July 28	954	198.8	Do.
Do	1923	Mar. 15	480	do	100	July 19	785	163.5	Do.
Do	1924	do	480	do	100	Aug. 9	672	140.0	Do.
Cucumbers:			*Hills*	*Feet*					
Davis Perfect	1920	May 10	15	6 by 4	65	Aug. 7	45	30.0	Fruits.
Fordhook Famous	1921	do	14	do	100	Aug. 9	75	53.6	Pounds.
Do	1922	do	15	do	100	Aug. 1	151	100.7	Do.
Do	1923	do	15	do	100	July 14	643	428.7	Do.
Do	1924	May 14	15	do	75	Aug. 14	150	100.0	Do.
Muskmelons:									
Emerald Gem	1920	May 10	10	6 by 4	50	Sept. 13	18	18.0	Fruits.
Do	1921	do	15	do	80	Aug. 20	28	18.7	Do.
Do	1922	do	15	do	100	Aug. 29	42	28.0	Do.
Do	1923	do	15	do	100	do	91	60.7	Do.
Do	1924	May 14	15	do	85	Sept. 27	18	12.0	Do.
Pumpkin:									
Sugar	1920	May 10	28	9 by 8	100	Sept. 28	672	240.0	Pounds.
Do	1921	do	28	do	85	Sept. 21	652	232.9	Do.
Do	1922	do	28	do	100	Sept. 8	651	232.5	Do.
Do	1923	do	28	do	100	Sept. 20	600	214.3	Do.
Do	1924	May 14	28	do	98	Sept. 28	1,281	457.5	Do.
Squash, summer:									
Cocozelle	1920	May 10	15	6 by 4	100	July 25	28	18.7	Fruits.
Do	1921	do	14	do	7	Aug. 2	6	4.3	Do.
Do	1922	do	10	do	90	July 31	40	40.0	Do.
Do	1923	do	10	do	75	Aug. 17	14	14.0	Do.
Do	1924	May 14	10	do	50	Aug. 11	24	24.0	Do.
Squash, winter:									
Golden Hubbard	1920	May 10	28	9 by 8	100	Sept. 18	1,485	530.4	Pounds.
Do	1921	do	28	do	0		0	0	
Do	1922	do	28	do	100	Sept. 8	560	200.0	Do.
Do	1923	do	28	do	100	Sept. 20	572	204.3	Do.
Do	1924	May 14	28	do	90	Sept. 28	900	321.4	Do.
Watermelons:									
Fordhook Early	1920	May 10	24	do	75	Sept. 1	368	153.3	Do.
Do	1921	do	24	do	85		([5])		
Do	1922	do	24	do	100	Sept. 2	600	250.0	Do.
Do	1923	do	24	do	100	Sept. 13	[6] 180	75.0	Do.
Do	1924	May 14	24	do	65	Sept. 20	[6] 250	104.2	Do.

[5] Yield good, but crop was stolen.

[6] Part of the crop was lost by trespass.

Some vegetables succeeded better than others, and some were better in some seasons than they were in others, but the only failure due to growing conditions during the five years was with late-planted cauliflower. There were some failures in obtaining stands, and some yields were affected considerably by impure, mixed, or mislabeled seed. Some crops were lost in whole or in part, and the determination of the yields was interfered with by trespass.

The favorable conditions afforded by the rotation system resulted in distinct improvement in the quality and size of the products. This result was more noticeable than increases in yields, as the yields were determined to a large extent by seasonal conditions.

Little trouble has been experienced with insects and plant diseases. The insects which it became necessary to combat were the pale western cutworm (*Agrotis* spp.), the green cabbage worm (*Pontia rapae*), the striped cucumber beetle (*Diabrotica vittata*), blister beetles (*Lytta* spp.), and the Colorado striped potato beetle (*Leptinotarsa decemlineata*).

Poisoned-bran bait was effective with the cutworms, and sprayings with arsenate of lead solutions kept the other insects in check. Plant diseases were very rare, being confined to potato scab and bean blight in very mild forms.

Directions for the control of the most common insects and diseases of the home vegetable garden are given in Farmers' Bulletin No. 1371, which may be obtained free from the Office of Information, United States Department of Agriculture, Washington, D. C.

The data on yields given in Table 3 are assembled in two other tables. Table 4 gives the total quantity of each vegetable produced in the acre garden each year. This table shows the variation in production of the different vegetables from year to year and brings together for ready reference the total production of the acre under the plan followed.

FIG. 4.—Shell beans, wax beans, and peas in the legume-crop plat of the acre garden on July 25, 1924

Table 5 gives the rate of yield of each vegetable each year per 100 feet of row or 10 hills. It furnishes a basis from which one may determine the quantity of any vegetable to plant to meet individual needs. The yields per acre are not shown, as it is not the purpose of this bulletin to advocate commercial production. Approximations of the yields per acre can be calculated, however, from the data given in the tables. If the rows are 3 feet apart, 100 feet of row occupies 300 square feet. An acre contains 43,560 square feet, or about 145 times the above area. It follows that with rows spaced 3 feet apart the rate of yield per acre is approximately 145 times the rate per 100 feet of row. The rate of yield per acre for any spacing can be calculated in similar manner.

The quantitative results are set forth in full in the tables and are not discussed in detail, but in the following paragraphs the general results with each vegetable are considered. These summaries utilize not only the results obtained for five years from the rotation garden, but also those obtained during investigations with vegetables for the preceding six years.

Asparagus.—Asparagus is well adapted to dry-land culture. A level piece of ground, to catch and store all precipitation during the season, and wide spacing, from 4 to 5 feet between the rows, to facilitate thorough and frequent horse cultivation, have proved to be the best aids to success at the field station. The

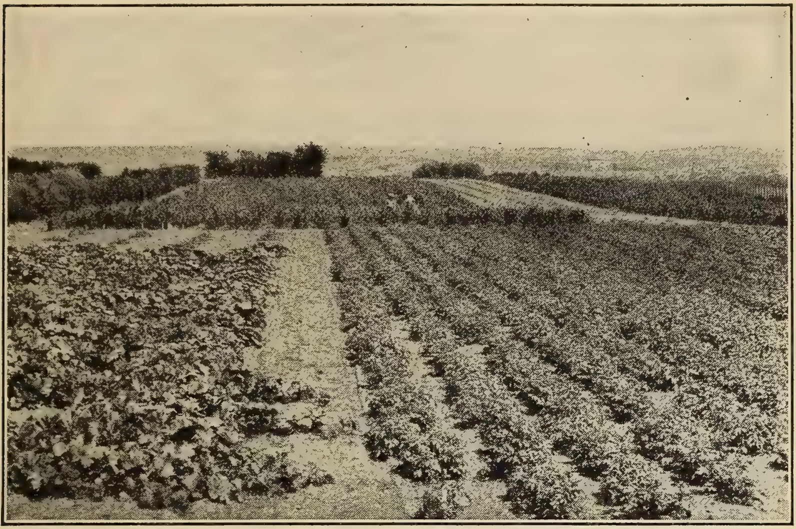

FIG. 5.—Cucumbers, melons, pumpkins, squashes, and potatoes in the plat for vine crops and early potatoes in the acre garden on July 25, 1924

TABLE 4.—*Total yield of each vegetable in the acre garden at the Northern Great Plains Field Station, Mandan, N. Dak., for each of the years from 1920 to 1924, inclusive*

Vegetable and class	Unit of measure	Total annual yields				
		1920	1921	1922	1923	1924
Beans:						
Shell	Pounds	107	18	120	105	110
Wax	Quarts	190	42	523	375	429
Beets:						
Early	Pounds	150	156	268	190	355
Winter	do	218	207	558	420	613
Cabbage:						
Early	do	485	361	1,087	178	714
Winter	do	195	530	1,062	0	1,186
Carrots	do	145	317	895	622	290
Cauliflower:						
Early	do	46	28	135	4	106
Fall	do	8	0	81	0	92
Cucumbers	do	[1] 45	75	151	643	150
Eggplant	Fruits	---	---	---	112	9
Muskmelons	do	18	28	42	91	18
Onions	Pounds	361	388	897	1,332	1,195
Parsnips	do	67	97	335	450	429
Peas	Quarts	29	49	160	131	235
Peppers	Fruits	---	---	---	---	179
Potatoes	Pounds	800	(2)	1,125	1,138	1,068
Pumpkins	do	672	652	651	600	1,281
Rutabagas	do	135	75	300	500	457
Squash:						
Summer	Fruits	28	6	40	14	24
Winter	Pounds	1,485	0	560	572	900
Sweet corn	Ears	242	500	1,400	1,568	2,500
Tomatoes	Pounds	458	354	954	785	672
Watermelons	do	368	(3)	600	180	250

[1] Fruits

(2) Yield good, but the record was lost.

(3) Yield good, but the crop was stolen.

TABLE 5.—*Rate of yield per 100 feet of row or 10 hills (vine crops) of each vegetable and variety in the acre garden at the Northern Great Plains Field Station, Mandan, N. Dak., for each of the years from 1920 to 1924, inclusive*

Vegetable, class, and variety	Unit of measure	Rate of yield				
		1920	1921	1922	1923	1924
Beans, shell:						
Pilot	Pounds	6.6	1.3	8.3	7.3	8.6
Great Northern	do	6.8				
Beans, wax:						
Saddleback (first planting)	Quarts	24.1	1.6	52.5	37.2	30.9
Saddleback (second planting)	do		3.8	38.8	32.2	41.9
Kidney (first planting)	do	13.4	3.8	59.1	24.1	32.2
Kidney (second planting)	do		4.1	13.1	23.8	29.1
White	do	21.9				
Beets, early:						
Eclipse	Pounds	46.9	48.8	83.8	59.4	110.9
Beets, winter:						
Detroit Dark Red	do	68.1	64.7	174.4	131.3	191.6
Cabbage, early:						
Copenhagen Market	do	(1)	170.0	438.1	87.5	331.3
Jersey Wakefield	do	101.0	55.6	241.3	23.8	115.0
Cabbage, fall:						
Copenhagen Market	do	60.9	89.1	191.9	0	270.0
Enkhuizen Glory	do		153.1			
Surehead	do			280.0		
Autumn King	do				0	
Danish Roundhead	do					201.3
Carrots, Chantenay:						
Early planting	do			228.8	118.8	37.5
Midseason planting	do	45.3	94.4	214.4	190.0	76.3
Late planting	do		103.8	116.3	80.0	67.5
Cauliflower, early:						
Burpee's Best Early	do	28.8	17.5	84.4	2.5	66.3
Cauliflower, fall:						
Snowball	do	5.0	0	50.6	0	
Dry Weather	do					57.5
Cucumbers:						
Davis Perfect	Fruits	30.0				
Fordhook Famous	Pounds		53.6	100.7	428.7	100.0
Eggplant:						
Black Beauty	Fruits				70.0	11.3
Do	Pounds				181.3	17.5
Muskmelons:						
Emerald Gem	Fruits	18.0	18.7	28.0	60.7	12.0
Do	Pounds		30.0	32.7	148.0	22.0
Onions:						
Australian Brown	do	21.1		25.8		
Southport Yellow Globe	do	23.5	20.2	60.4	75.7	67.9
Parsnips:						
Guernsey	do	20.9	30.3	104.7	140.6	134.1
Peas:						
Alaska	Quarts	4.4	7.5	14.1	12.2	27.5
Notts Excelsior (first planting)	do	4.6	3.4	22.2	16.3	22.2
Notts Excelsior (second planting)	do		4.4	13.8	12.5	23.8
Peppers:						
Ruby King	Fruits					223.8
Do	Pounds					35.0
Potatoes:						
Early Ohio	do	64.5	(2)	78.1	79.0	74.2
Pumpkin:						
Sugar	do	240.0	232.9	232.5	214.3	457.5
Rutabagas:						
Golden Neckless	do	84.4	46.9	93.8	156.3	142.8
Squash, summer:						
Cocozelle	Fruits	18.7	4.3	40.0	14.0	24.0
Do	Pounds				41.0	93.0
Squash, winter:						
Golden Hubbard	do	530.4	0	200.0	204.3	321.4
Sweet corn:						
Golden Bantam (first planting)	Ears	[3] 9.5	2.3	54.7	71.9	96.1
Golden Bantam (second planting)	do		36.7	54.7	57.9	113.4
Tomatoes:						
Earliana	Pounds	95.4	73.8	198.8	163.5	140.0
Watermelons:						
Fordhook Early	do	153.3	(4)	250.0	75.0	104.2

[1] Copenhagen Market and Jersey Wakefield raised in 1920, but yields were not determined separately.
[2] Good yield of potatoes in 1921, but the record was lost.
[3] Yields from two plantings not determined separately.
[4] Good yield of watermelons in 1921, but the crop was stolen.

Reading Giant variety is very good. Other good varieties are Washington, Conover's Colossal, and Giant Argenteul.

Beans.—Both shell and snap-podded beans do well in an average season. If there is a protracted dry period in the latter part of June and the early part of July, the plants will set pods so late that there is danger of the shell beans not maturing before frost. Home-grown seed selected from early-maturing plants is of importance in obtaining a crop regularly. The Pilot (navy) and Great Northern (marrow) varieties are dependable for dry beans. Burpee's Saddleback, German Black Wax, and Burpee's Kidney are good wax-pod varieties; and Stringless Green Pod, Refugee, and Valentine, of the green-podded class, succeed equally well.

Beets.—About the only difficulty met in the culture of beets has been lack of germination in certain seasons. If a good stand is obtained, beets, both early bunching and those intended for winter storage, do very well. The Eclipse and Extra Early Egyptian varieties are good for bunching, and the Detroit Dark Red and Crimson Globe with their uniformly smooth turnip-shaped roots can be recommended for winter storage. For this purpose they should be planted rather late in the season, as otherwise they grow too large and coarse for table use.

Celery.—Celery does not always succeed under dry-land conditions. Some means for watering or irrigating the plants immediately preceding the blanching process has been found necessary for the best results. Golden Self-Blanching and Silver Self-Blanching varieties are dependable for an early fall crop, and Fordhook, Winter Queen, and Kalamazoo have been found good for winter storage.

Cabbage.—Cabbage has proved to be one of the most dependable and valuable vegetable crops at the field station. The early crop succeeds especially well. The fall crop may generally be depended on, but it requires more skill in management in order to prevent the bursting of the heads. The Wakefield varieties and Copenhagen Market are the best for the early crop, and Danish Roundhead, Enkhuizen Glory, Autumn King, and late-planted Copenhagen Market are good for fall and winter use.

Cauliflower.—The early crop of cauliflower succeeds well, but the heads are generally small. Late varieties and early varieties planted late for a fall crop as a rule were failures. Burpee's Best Early, Dwarf Erfurt, and Snowball are recommended as uniformly reliable varieties.

Carrots.—Carrots are very reliable. Good results are obtained from early, midseason, and late sowing. Some difficulty in obtaining a good stand has been experienced with seed planted after June 1 when the season was dry. Early-planted seed yields best, but the roots develop a strong flavor before they are harvested. The half-long, stump-rooted types succeed better than short or long rooted ones. The Chantenay variety is very reliable, as is also Half-Long Danvers.

Cucumbers.—Cucumbers respond to rich soil and a good supply of moisture. Both pickling and White Spine varieties succeed in an average season under dry-land conditions. Fordhook Famous, Davis Perfect, and other White Spine varieties have done well at the station, as has also Boston Pickling or Early Green Prolific.

Eggplant.—The eggplant is somewhat exacting as to cultural treatment, but once established in the field yields moderately well in an average season. Potted plants from 3-inch pots are desirable for the best results. The Black Beauty, Black Pekin, and Early Dwarf Purple are good varieties for the northern Great Plains.

Lettuce.—Leaf-lettuce varieties succeed well from early and midseason planting but give poor results from late-summer planting. Head-lettuce varieties succeed best from plants transplanted early in the spring, but some varieties produce a fair percentage of heads from early field sowing. Early thinning is necessary for good results with field-sown plants. Black-Seeded Simpson and Grand Rapids are good leaf varieties, and Wayahead, May King, Salamander, and Hanson are reliable heading varieties.

Muskmelons.—The muskmelon is not entirely reliable. The earliest varieties obtainable should be used, and if possible a light, sandy, well-fertilized soil should be selected. The Emerald Gem has been the most reliable variety, but fair results have been obtained from Eden Gem, Paul Rose, and Hackensack.

Onions.—From good to very good yields of onions have been obtained each year. Early thinning to 2 or 3 inches and frequent cultivation contributed much to the success. There was marked improvement in both yield and quality on soil that was well fertilized the previous season. The Globe varieties, especially the Southport strains, and Australian Brown have given uniformly good results, with a small percentage of scallions.

Parsnips.—Parsnips succeeded well every year. There was marked improvement in size with a corresponding increase in yield on rich ground. Improved Guernsey seems especially well adapted to the soil at Mandan, but Hollow Crown also has given good results.

Peas.—Both the smooth and wrinkled varieties of peas have been grown with resulting fair to good yields. On the whole, the seasons seem to be too hot and dry for this vegetable. There was a marked increase in yield and quality during the season of 1924, which was cool, with considerable precipitation in June. Dwarf varieties in general have given the best results. Notts Excelsior, Little Marvel, Gradus, and Laxtonian of the wrinkled and Alaska of the smooth-seeded varieties can be recommended.

Peppers.—Early varieties of peppers succeed well. Potted plants are earlier and generally do better than those taken directly from the seed bed. Ruby King, Neapolitan, and Chinese Giant are recommended.

Potato.—The varieties of potatoes tested at the station have given fair to good yields. Sprouted or "greened" tubers were from 10 to 14 days earlier than field-planted stock. Early Ohio and Irish Cobbler seem especially adapted to the region and are of excellent quality.

Pumpkin.—The Small Sugar variety of pumpkins produced very good yields every year. Other varieties produced fruit, but only a small percentage ripened before frost.

Rutabagas.—The yields of rutabagas have been extremely variable. In general the quality of the crop has been rather poor. Golden Neckless and Bangholm were of a little better quality than the other varities tested and succeeded best on an average.

Spinach.—Very good results have been obtained with spinach, but generally from spring planting only. The Victoria of the Savoy-leaved class and Viroflay of the long-stemmed type have given excellent results with ordinary field cultivation.

Squashes.—Both summer and winter squashes have done very well. Cocozelle and Bush Vegetable Marrow are excellent for use in the green state, and Fordhook and Golden Hubbard mature sufficiently early for winter storage.

Sweet corn.—Early varieties of sweet corn succeeded every year. Plantings up to the first week in June gave good yields. Golden Bantam heads the list for quality and yield; but the Cory varieties, Early June, and Extra Early White Mexican were also reliable.

Tomato.—Good crops of tomatoes have been obtained every year, especially from potted, staked, and pruned plants. The Earliana and Ponderosa varieties have given the best results, mainly on account of being almost immune to blossom-end rot. In fairly moist seasons Chalk's Early Jewel and its strains have done very well.

Watermelons.—Only the very earliest varieties of watermelon can be depended on to ripen in the average season. Fordhook Early, Cole's Early, Peerless, and Hungarian Honey generally ripened part of the crop.

SUGGESTIONS FOR GARDENING ON THE NORTHERN GREAT PLAINS

SELECTING THE SITE

Any piece of land having soil suitable to raise a good crop of corn may be selected. A level piece, or one having a very slight slope to the north or northeast, is most desirable, as on such ground there is less danger of washing out by heavy rains or drying out by hot winds. Protection from high winds, especially on the west or northwest side, is a very good thing, although perhaps not absolutely necessary. A row of Siberian pea trees, Tatarian maples, or Russian olives on the most exposed sides is not difficult to establish and should give the desired protection within three or four years from the time of planting. An ample area should be provided, in order to allow for wide spacing in planting and possible low yields through unforseen circumstances.

PREPARING THE SOIL

Deep plowing is very much to be desired. When part of the garden is manured the manure should be spread as finely and evenly as possible, then disked into the topsoil, and the whole turned under

7 or 8 inches deep. This operation should be performed in the fall just before the ground freezes. By late plowing insect eggs and larvæ are exposed to winter temperatures and killed, and the soil has an opportunity to become settled and compact before planting time in the spring. The manure is in the best condition if it has been stacked and composted the previous season. As early in the spring as the soil is in working condition it should be harrowed several times and smoothed with some kind of float or planker.

PLANTING SCHEDULE

Most of the common vegetables may be sown in the ground where they are to grow. Long-season or hot-weather crops must be started indoors and set out in the field later, when the weather becomes settled. Seeds that take a long time to germinate and are more or less frost resistant are planted as soon as the ground can be worked; examples of these are onions, parsnips, and carrots. Other seeds germinate within a few days, and the plants are easily injured or killed by frost. The planting of these should be delayed until most danger of frost is past. Examples of these seeds are beans, cucumbers, squashes, and melons. Some vegetables, such as rutabagas and carrots, are hardy and may be planted early in the spring, but if grown during the heat of the season they develop strong, disagreeable flavors, making them unfit for food. They are better planted as late in the season as possible, in order that they may make their maximum growth in the fall, when the weather is cool.

The suggested planting dates given in the following schedule are suited to the average season on the northern Great Plains:

Early cabbage, cauliflower, tomato, eggplant, peppers, and celery, March 15 to 20; indoors.

Head lettuce, April 1; indoors.

Smooth peas, onion, carrot, parsnip, lettuce, radishes, and spinach, April 14 to 20; outdoors.

Fall cabbage and cauliflower, April 25 to 30; indoors or in a coldframe.

Wrinkled peas, beets, and potatoes, May 1; outdoors.

Set out early cabbage and cauliflower, if well hardened, from May 1 to 7.

Sweet corn, wax beans, cucumbers, squashes, pumpkin, melons, and the second planting of lettuce, radishes, spinach, and carrots, May 7 to 10; outdoors.

Navy beans, May 14 to 16; outdoors.

Fall beets, rutabagas, the second planting of sweet corn, wax beans, wrinkled peas, and the third planting of carrots, May 25 to 28; outdoors.

Set out late cabbage, cauliflower, tomato, eggplant, peppers, and celery from May 20 to June 1.

SPECIAL CULTURAL METHODS

Some long-season vegetables are apt to be caught by frost before their maximum yield is produced. Special treatment calculated to hasten maturity is advisable for these. If labor is scarce such special treatment may be confined to tomatoes. These should be pruned to a single stem and trained to stakes for early ripening of the fruit. The pruning and staking should begin shortly after the plants are set in the open. Shoots growing in the axils of the leaves should be pinched out when about 2 inches in length. This causes less injury to the plant and is performed with greater ease than when they are allowed to develop farther. It will be found necessary to go over the plants every other day or so when in full growing vigor. The stem is tied to the stake immediately above a fruit cluster, to provide support when the fruits begin to develop. Figure 6 shows tomatoes pruned and staked in the garden at Mandan.

EQUIPMENT

In gardening to the best advantage adequate machinery and suitable tools will be found almost indispensable. These may be procured with a reasonable outlay of money. The following items of equipment are recommended:

A hotbed frame (6 by 12 feet), 4 standard hotbed sash (3 by 6 feet), a garden trowel, a steel dibble, a wheel hoe, a garden planter, a 9-shovel cultivator, rakes, hoes, etc.

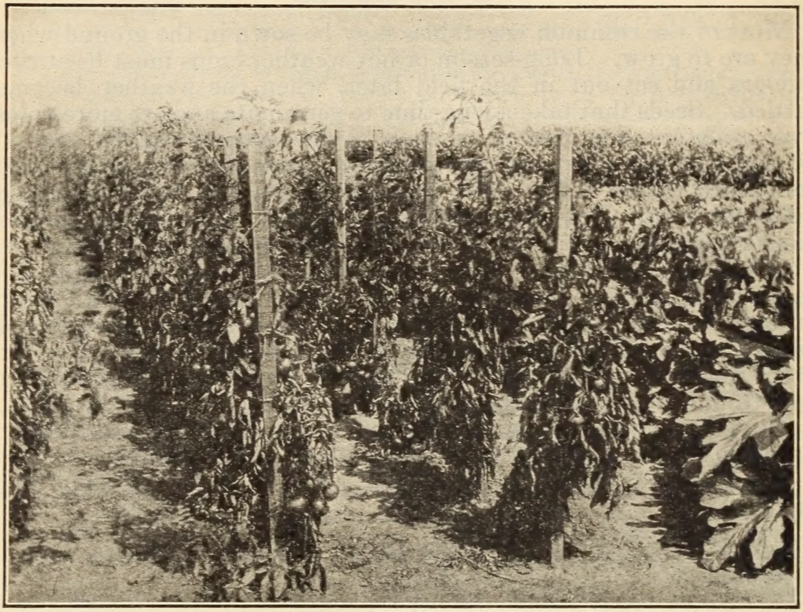

FIG. 6.—Pruned and staked tomatoes in the acre garden

CONCLUSIONS

More farm gardens are needed in the northern Great Plains. Comparative success may be attained every year under dry-land conditions by intelligent management. The yields are somewhat smaller than those obtained in more favorable sections, but this may be offset by planting larger areas. Man labor is scarce, so horse labor and machinery should be used as much as possible. One acre is ample in size for an average family of five. Seed and plants for a garden of this size may be provided for approximately $15 to $20. Returns should average in value around $250. The essentials may be briefly summarized as follows:

Make a definite planting plan, in order that sufficient plants and seeds may be provided.

Follow a system of crop rotation to provide the necessary food requirements for special crops and to aid in eliminating plant diseases and insect pests.

Select early maturing varieties of vegetables. The harvest season may be extended by succession plantings of most of these.

Practice wide spacing and thorough and clean cultivation, in order to conserve all available moisture.

Keep crops growing with as little check as possible, making use of insecticides and fungicides as needed.